Circuit Basics

Electric circuits are arrangements of conductors and components that permit electrical current to flow. A circuit can be as simple as a battery and lamp or as sophisticated as a computer.

Big ideas:

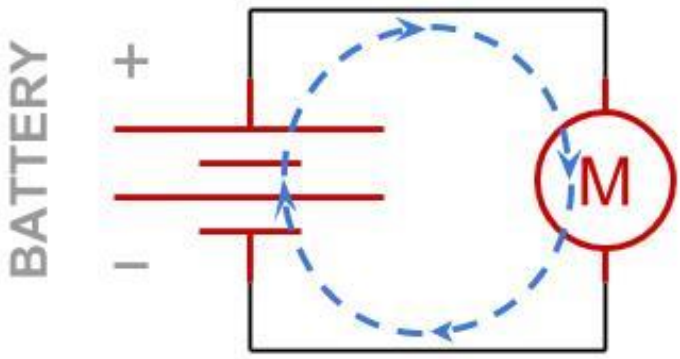
- Electrical **power** is defined by a **voltage** and a **current**.
- Electric current needs to flow in a **circuit**. The terms **open**, **closed**, and **short** circuit are used to describe special circuit conditions.
- Circuit components that are being powered make up the electric "**load**".
- Circuit elements can be arranged in a **series** or **parallel** fashion.

Voltage is a measurement of the electrical potential produced by a power source such as a battery or the utility grid connected to the wall outlet. It can be thought of as the amount of energy in the electrons. Voltage is measured in volts (V). Household batteries typically range from 1.5 V to 9 V. Electric grid power is typically at 110 V.

Current is the flow of electrons in a circuit, and can be thought of as the rate of electrons moving through the circuit. Current is defined as the flow of electricity from the positive (+) end of the power source to the negative (-) end. It is measured in amperes (A). Some approximate current measures are: small lamp with a 3V battery: 0.1 A, laptop computer: 2 A, vacuum cleaner: 10 A.

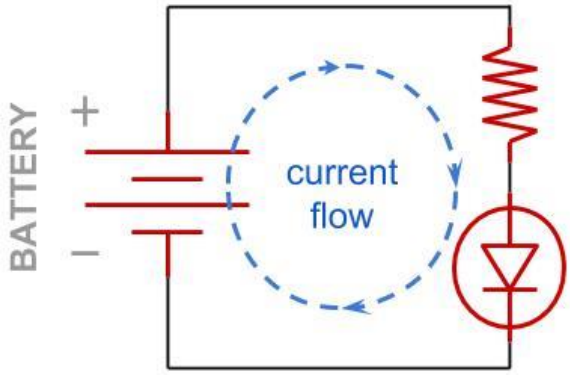
Electric Power can be calculated as Voltage x Current. Combining the mental models of voltage and current we see that power can be thought of as the rate of energy moving through the circuit. The units are watts (W). Electrical devices often have the power requirements written on them. Incandescent lightbulbs are often 60 W. New LED lightbulbs are typically 13 W.

Electricity can only flow in a **circuit**. A circuit is a conductive path that starts at the positive (+) end of the power source and ends at the negative (-) end. Electronic components, like lamps and motors, can be inserted into that path and the electricity will do some work, like lighting up the lamp or spinning the motor. The **Load** in a circuit consists of the electric components that we want to power such as lights, motors, and speakers. Switches are often used to stop and start the current to the components.

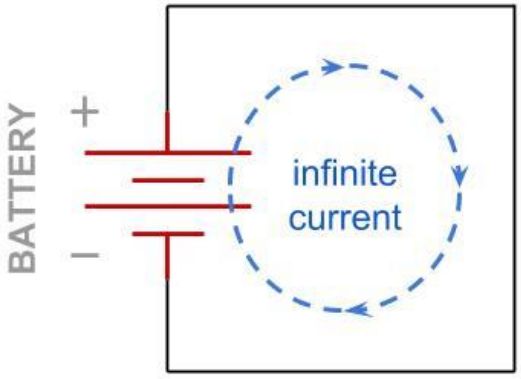


Circuit Basics

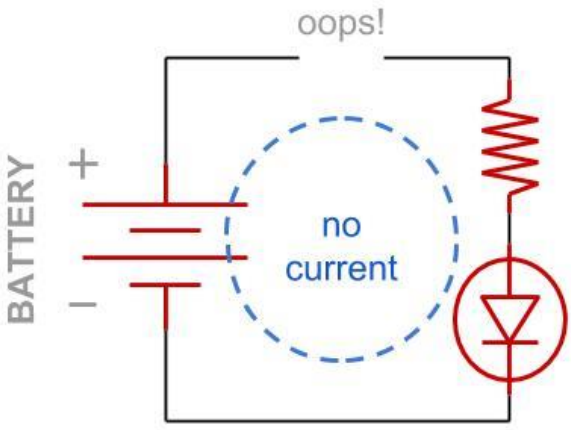
Closed Circuits are proper circuits including a power source and a set of appropriate components. In a useful circuit the load is matched to the power source. That means the power source provides the appropriate amount of voltage and current to run the desired electrical devices.



Short Circuits happen when the positive and negative ends of the battery are connected together. Sometimes this happens when the wire ends of a battery holder touch each other. In this case the batteries heat up quickly, melt the holder, and can burn a person holding it. Sometimes the short circuit is not obvious and is detected by a burning smell or components not functioning as expected. In that case, remove the power source and check the circuit.

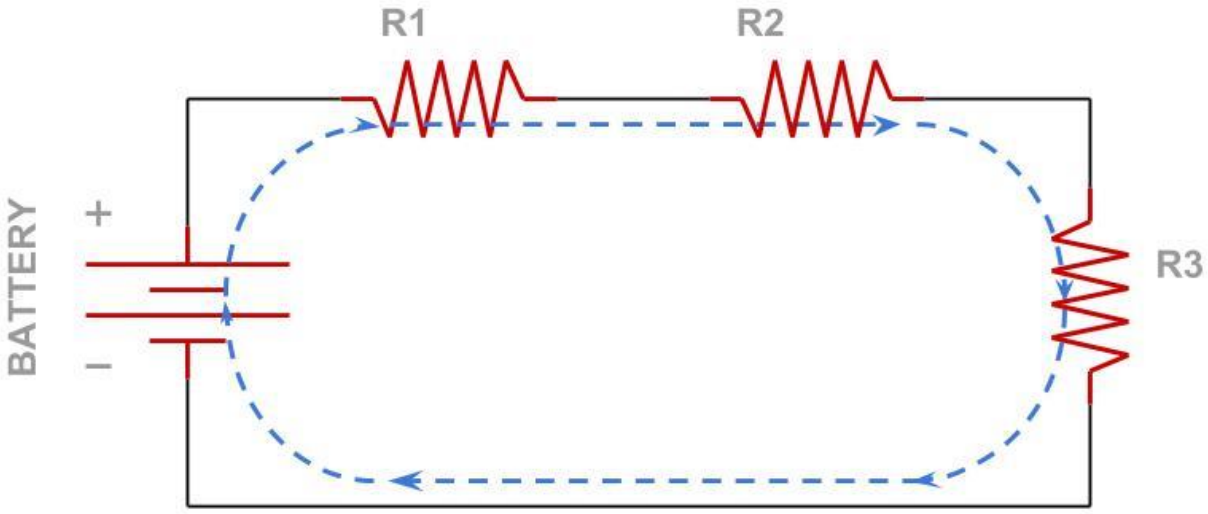


An **Open Circuit** is the opposite of a short circuit**.** This is a circuit where the loop isn't fully connected – and therefore it isn't really a circuit at all.



Series Circuits

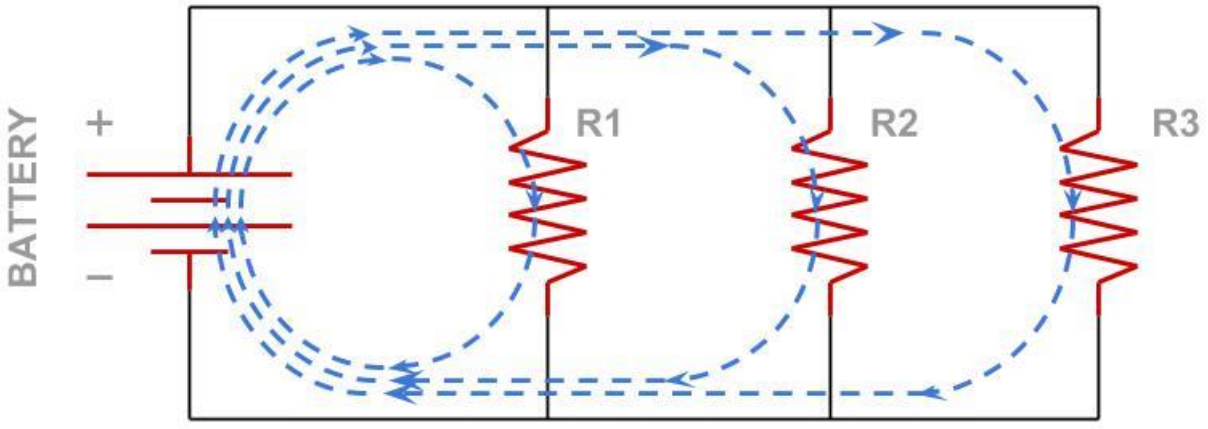
Two components are **in series** if the same current flows through them. Here's an example circuit with three series resistors:



There's only one way for the current to flow in the series circuit. Current starts at the (+) end of the battery and flows through components before returning to the (-) end of the battery. Note that the current is constant through each component and the battery.

Parallel Circuits

Components are in parallel when they create separate paths for current to flow through. In parallel circuits all components in parallel all have the same voltage dropping across them, but are likely to have different currents. This example shows 3 parallel resistors. Note that the currents that go through each component sum up at the battery.



Parts of a Circuit

The elements of any circuit can fall into one of the four categories as described here.

The **Source** is the power source, often a battery or other DC power supply, but possibly an AC source such as a wall outlet.

The **Load** is the electrical device that is being used in the circuit. It "loads" down the circuit and slows the current. Loads can be motors, lamps, LEDs, buzzers, or any of a wide variety of electrical components.

Conductors are the pieces that intentionally conduct electricity. They can be wires, traces on a printed circuit board, or conductive thread, copper tape, or any other conductive material.

The **Control** elements are components that connect or disconnect parts of the circuit and direct the electricity in a particular way. Controls can be switches that connect and disconnect conductors, or variable devices such as potentiometers, photoresistors, thermistors, etc. that limit current as their resistance changes.